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ABSTRACT

A 4-year program of naturalistic research on science teaching and learning was conducted in Australia. This program comprised a project entitled Teaching and Learning Science in Schools (TLSS), which ran from 1987-89, and a year of follow-up studies in which some of the major findings from the project were explored further. Participants included 5 teachers and 200 grade 6 students from 4 primary schools; 41 teachers and over 2,000 secondary students; and 2 teacher educators, 13 teacher trainees, 2 lecturers, and over 200 first-year college chemistry students. Three main themes that guide improvement in classroom practice arise from the findings of this study: (1) the interdependence between constructivist processes of purposeful inquiry based on reflection and outcomes associated with enhanced metacognition; (2) the importance of balance between cognition and affect for effective teaching and learning; and (3) the notion of challenge as a focus for conceptualizing themes 1 and 2. Nine features that influence cognitive and affective components of challenge were identified. These features are seen as important subjects for teacher and student reflection and action. (KR)

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Challenge: A focus for improving teaching and learning[1]

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Challenge: A focus for improving teaching and learning

ABSTRACT

In this paper, we report findings from a 4-year program of interpretive research on teaching and learning. Three main themes that guide improvement in classroom practice arise from these findings. These themes are: the interdependence between constructivist processes of purposeful enquiry based on reflection, and outcomes associated with enhanced metacognition; the importance of balance between cognition and affect for effective teaching and learning; the notion of challenge as a focus for conceptualising themes 1 and 2. Nine features that influence cognitive and affective components of challenge are described. These features are important subjects for teacher and student reflection and action.

Introduction

The subject of this paper is a four-year program of naturalistic research on science teaching and learning. This program comprised a major project entitled Teaching and Learning Science in Schools (TLSS), which ran from 1987-89 and, subsequently, a year of follow-up studies in which some of the major findings from the project were explored further.

We have already reported the aims and some initial findings of TLSS (White, Baird, Mitchell, Fensham, and Gunstone, 1989). Generally, the aims were to know more about the mechanisms that underlie the processes of teaching, learning, and personal change. As the research program has now concluded, we can provide a more comprehensive review of the findings. In this paper, we integrate these findings by setting them within three interrelated themes to inform and guide classroom practice. These themes are:

1. The interdependence between constructivist processes of purposeful enquiry based on reflection, and outcomes related to enhanced metacognition (knowledge, awareness, and control of personal practice);
2. The importance of balance between cognition and affect for effective teaching and learning;
3. The notion of challenge as a focus for conceptualising balance between cognition and affect, for diagnosing quality in teaching and learning, and for structuring improvement in classroom practice.

In the next section, we describe how the first of these themes determined the overall rationale and design of the TLSS project. Subsequently, we discuss how project findings led us to themes 2 and 3. Finally, we describe how, in 1990, we further explored theme 3.

Rationale and design of TLSS

Rationale. The style of our research is interpretive (Erickson, 1986), and directed to the meanings that underlie classroom actions. The primary focus and goal of our research is quality in classroom teaching and learning.

Our beliefs regarding the nature of quality guided our approach - we associate quality in teaching or learning with adequate metacognition, an outcome that is achieved through coordinated reflection and action by the teacher or learner. For instance, when a person learns effectively, he or she may attend and observe carefully (action), ask evaluative questions regarding these observations and select procedures to determine answers to these questions (reflection), apply these selected procedures (action), evaluate the results, and make decisions based on this evaluation (reflection) and enact these decisions (action) (- see Baird, 1991). Through such a process of purposeful enquiry the person will know more about the nature and process of learning, will be aware of the purpose and progress of the current learning task, and will make informed decisions regarding appropriate action.

Both cognition and affect are inherent to the process (purposeful enquiry), and its outcome (metacognition). For example, interests and beliefs directly influence choice of cognitive strategies and intellectual skills, and feelings of confidence, accomplishment, and satisfaction accompany the awareness and control that are generated.

Taking a broader view, we consider that purposeful enquiry leading to enhanced metacognition is the route to an individual's personal and professional improvement. The general goal of our research was to explore ways of fostering this process in everyday classrooms. In order to do this, we needed to enter into close, continuing collaboration with teachers and students. The purpose of this collaboration was to provide adequate time, opportunities, guidance, and support for individual and group change. As we will describe, the design and manner of implementation of TLSS (in

terms of its duration, number and types of participant, nature of their participation, and range of techniques and assessment measures employed) provided for these conditions

Design. In terms of research focuses, teachers and students acted both as subjects and objects of the research. Research methods were based on the participants reflecting on themselves and their practice. Members of the project team actively collaborated with them in this reflection; collaboration was either 1:1 (teacher or student and project team member), or in a group (often comprising all three types of participant).

Depending on the procedure, the subject of reflection varied - it may have been particulars of classroom practice, perspectives ("theory") that may guide this practice, or even what it is to be a teacher or a student. The latter subject differs from the first two in that it is more phenomenological, directed to understanding about personal lived experience, than the more explanatory focus of the reflections on practice. Research based on both reflection on practice and phenomenological reflection employed a variety of data-gathering methods appropriate to naturalistic, interpretive research. Teachers kept diaries, completed periodic written evaluations, and entered into regular interviews and collaborative research discussions. Students completed written evaluations and questionnaires, and participated in classroom discussions and regular individual and small-group interviews.

The overall number of school participants in the project were:

Primary:	5 teachers and 200 grade 6 students from four schools;
Secondary:	41 teachers and over 2,000 students from Years 7-11 at 15 schools;
Tertiary:	2 teacher educators and 13 Dip.Ed. teacher trainees, and 2 Chemistry lecturers and over 200 first-year Chemistry students, at Monash University.

For different participants, the nature and extent of collaboration varied. Some participants simply completed a questionnaire or were interviewed on one or at most a few occasions. For 26 practising teachers, the 13 teacher trainees, and over 500 Year 7-10 students, however, involvement was more intensive and longer-term, and lasted for periods from several months to the whole three years.

Eight research studies were conducted in 1987, eight in 1988, and fourteen in 1989. In this paper, we shall concentrate on results from research at the secondary level. Separate research studies were related because of the nature of the action research - findings from one study influenced the design of the next. Because the consultants were collaborating in studies in several schools at the one time, the influence extended between schools. For example, our increasing attention in 1988 to students' interest and extent of challenge was based on outcomes of research in one school during 1987. Subsequently, the notion of balance between cognition and affect was clarified through research centred in two other schools.

In the 1990 follow-up studies, a further 7 teachers and 35 science students in grades 7-10 from four schools collaborated closely with us for five months in order to elaborate the notion of challenge (described below). Additionally, a detailed questionnaire on challenge was completed by approximately 4000 students in grades 7-10 from 10 schools.

Similarity and synthesis: an interpretation of findings from TLSS

The numerous research studies in TLSS generated large quantities of data. Progressively, as these data emerged, so did our realization that they included striking commonalities and regularities over time, place, and type of participant. We have used these commonalities and regularities to build a view of quality teaching, learning, research, and change, a view that we hope may assist others who seek to improve quality and educational theory and practice. It is a view that emphasises similarity and synthesis in the conception, practice, and research of classroom practice.

In Figures 1 and 2, we have incorporated the commonalities and regularities in findings within two conceptual schemes: The first is an overview of the processes and conditions that seem to provide for quality, the second contains details of the notion of challenge.

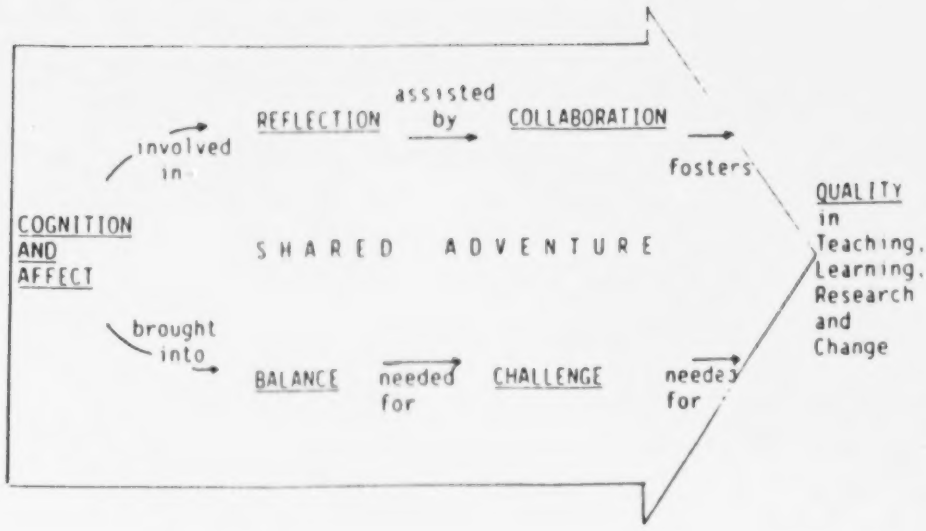

Figure 1. Quality through shared adventure: some key concepts

In Figure 1, the arrow signifies progress towards quality in teaching, learning, research, and change. The upper path relates to a process for, and the lower path to some conditions of, its attainment. Both paths build on cognition and affect of the individual. The upper path incorporates the arguments regarding purposeful enquiry, metacognition, and collaborative endeavour (theme 1) mentioned in the previous section - arguments that underpinned the rationale, for, and design of, TLSS. The lower path represents some of the most important findings of the project, and the bases for themes 2 and 3. In order to achieve quality, cognition and affect need to be brought into balance. The notion of challenge is a focus for conceptualising this balance between cognition and affect, for diagnosing quality in teaching and learning, and for structuring improvement in classroom practice. When both paths operate, we have shared adventure - a process of collaborative reflection that builds on positive individual challenge. As we shall mention shortly, shared adventure is one way of defining quality. First, however, we shall clarify the notion of challenge, according to Figure 2.

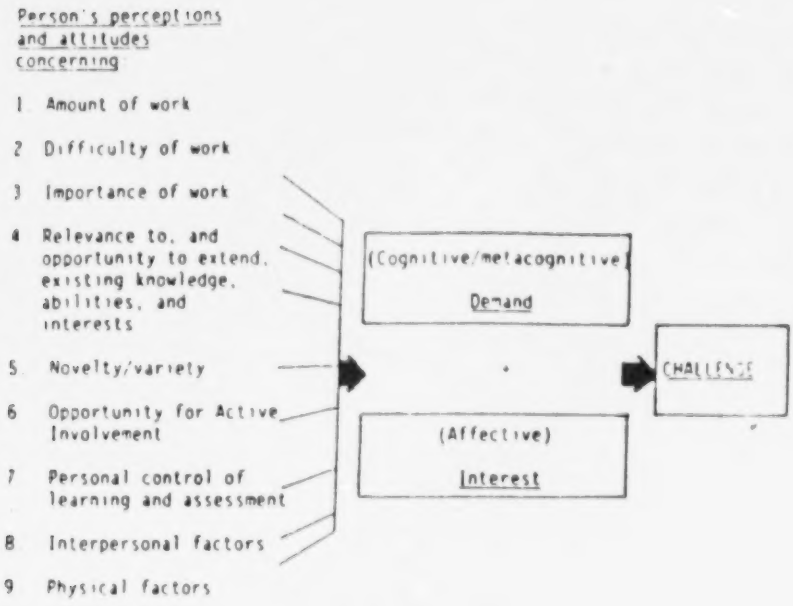

Figure 2: Challenge

Throughout all of the different studies that made up the TLSS project, teachers and students across grade level, subject, school, and time repeatedly emphasised certain aspects of lesson content and context as being important influences on the levels of their application, understanding, and enjoyment. In Figure 2, these aspects are considered in relation to the extent to which the person is positively, productively challenged by the task. In all, there are nine categories of influence: four are about the work (its amount, difficulty, importance, and relevance and opportunity to extend existing knowledge), three concern activities (their novelty and variety, who controls them, and the amount of mental and physical activity in them); two relate to the context in which the teaching/learning event occurs (interpersonal and physical factors). As shown in Figure 2, this notion of challenge accommodates the joint influence of cognition and affect on action. We envisage Challenge as comprising to main components - a cognitive/metacognitive Demand component and an affective Interest component. The nine features above interact to influence the levels of these two components of challenge. If cognitive Demand is High (but not too high), and the level of Interest is High,

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challenge is positive and productive, and the person engages in the task effectively and enthusiastically. Alternatively, there are three situations in which such positive, productive challenge does not exist. If Demand is High, but Interest is Low, the best situation possible is that the person complies (albeit unwillingly) with externally-enforced requirements. If Demand is Low, while Interest is High, the person is frustrated and unextended. If Demand if Low and Interest is also Low, the person may not engage in the task at all. In each of these last three situations, challenge is either lacking or absent

Many people, students especially, tend to describe at least some of their work as "boring". We have come to realise, however, that this word may describe quite different situations. Students may label each of these last three situations as boring, even though the word has a fundamentally different meaning in each case. Thus, boredom may be a multi-faceted outcome that derives from conditions relate to inadequate challenge, rather than a unitary concept related to lack of interest.

A small sample of findings from TLSS that support themes 1, 2 and 3

It is impossible to provide here a comprehensive account of the evidence that led us to themes 1, 2 and 3. For theme 1, we have reported elsewhere some evidence from TLSS that demonstrates the efficacy of various collaborative procedures for stimulating purposeful enquiry and enhanced metacognition for teachers and students (e.g. White et al, 1989; Baird, Fensham, Gunstone, & White, 1991). Further evidence in support of this theme will not be given here. For themes 2 and 3, however, we shall mention a few of the studies that indicate the importance of balance between cognition and affect and, particularly, of challenge, for quality classroom practice. A more detailed consideration of these and other studies are given in Baird (in press).

Evidence for theme 2: The Joint Lesson Evaluation. This procedure involved intensive collaboration between a teacher and the first author. Four teachers from one school collaborated individually over a sequence of six typical science lessons. After each lesson, each partner completed an 8-page form that required detailed review of the nature of, and interaction among, curriculum content, lesson activities, and teaching and learning behaviours and outcomes. Perceptions were then compared, and issues that arose discussed. One such issue related to each partner's responses to a question on the form. This question required the person to select, from a list of 36 words, those that he or she

believed described the way the teacher had taught the lesson. In their responses, both partners often highlighted cognitive (content-related, competence) aspects (by choosing words such as logical, well-paced, accurate, and thorough), rather than affective (interpersonal, humanistic) aspects, as described by words such as caring, stimulating, sensitive, and supportive. Both the teacher and the consultant agreed that this disproportionate attention to cognitive aspects of teaching was limiting teaching effectiveness. Also, the teachers came to realise that increasing the affective dimension of their teaching, by providing for more perceptive, sensitive, and motivating interactions, would require considerable commitment and effort. Some teachers were prepared to invest this effort, others were not.

Evidence for theme 3: questionnaires and discussions on challenge:

"I think science is boring. All we do is write, write and more writing. We have long tedious discussions. And maybe twice a term we would do something a little different. We would see the result of an experiment done by the teacher. Now, when I look at the timetable and see that we've got science, I don't really look forward to it like I used to when I was in grade 6."

"I thort (sic) we would do heaps of experiments but I find it really boring. I think we have only done 2 experiments this year, and they only are with water. The teachers says we don't do them much because [we] were being stupid, but [we] were only stupid because [we] were excited because we don't do them much."

"If I want to boil water I'll use a kettle, and I know about how young are born and how plants grow because my mum has been pregnant twice and we have a garden."

The quotes above are three of many made by students in an end-of-year evaluation of grade 7 Science. For these students, grade 7 Science was a great disappointment, especially as they had enjoyed science at grade 6, and had looked forward to doing it next year. Obviously, for students to react this way, something was seriously wrong with science classwork. Such quotes as these indicate a mismatch - a mismatch between the teacher's choice of topics, and expectations of the students, and what they are interested in and capable of.

During 1988 and 1989, more than one thousand grades 6-10 students were surveyed by questionnaires that probed their perceptions regarding various aspects of the

demand and interest of their science classwork. Over 20 of their teachers also responded to questionnaires, were interviewed about themselves and their teaching, and gave their interpretations of and reactions to collated student questionnaire data. Space is insufficient for a detailed account of the findings, however certain general trends were clear. One such trend was that, as students continued their science studies over these years, most of them reported a steady level or an increase in aspects related to cognitive demand, but a decrease in aspects related to interest, enjoyment, and satisfaction. In broad terms, students were becoming progressively less productively challenged by the science they were doing. Particularly, they complained that too often science involved abstract, "academic" topics that had little perceived relevance to personal interests, needs, or concerns, and that were required to be learned in a manner that emphasised emotional detachment and limited active involvement and commitment.

Early in 1990, the first author collaborated closely with 2 teachers and four of their grade 9 classes, in order to diagnose the existing level of challenge in lessons, and the level of each of the aspects that bear on it (as given in Figure 2). First, in the absence of the teacher, each student anonymously assigned him- or herself to one of the four general categories regarding combined levels of Demand and Interest discussed earlier (Demand High, Interest High; Demand High, Interest Low; Demand Low, Interest High; Demand Low, Interest Low). As a class, the students and the author then discussed the distribution of students across these four categories, and the significance of this distribution. For most of the classes, the majority of students had placed themselves in the Demand High, Interest Low group. Next, students responded anonymously about whether they felt that the level of each of the nine factors (as shown in Figure 2) was either satisfactory or not satisfactory. Again, a class discussion ensued, in which students and the author considered the overall patterns of response. In each class, a few (but not always the same few) factors emerged as being unsatisfactory for many students. At this time, the teacher was invited back into the classroom, and informed of the results. Then, the whole class - teacher and students - discussed what might be done to improve the situation. Thus, in this procedure, students reflected on science content and activities in a systematic, diagnostic manner, according to the components of challenge. Teachers then joined the students to remediate the aspects of classwork that had been identified as unsatisfactory. Both teachers and students enjoyed the activity, and participated in it enthusiastically. They worked together to become more aware of, and to take more

control over, the quality of science classwork. The nature of this activity leads us to the notion of shared adventure.

Quality as shared adventure

When class conditions are such that teachers and learners individually experience positive, productive challenge in the work they do, and are engaged in a process of careful reflection carried out collaboratively with others, you have Shared Adventure (see Figure 1). The findings of TLSS support the view that this notion of shared adventure is a desirable goal for teaching and learning.

In his book Sharing nature with children Cornell (1979) advances some suggestions for good elementary nature-study teaching. We believe that these suggestions, which connote a spirit of shared adventure, hold true for education more generally. Cornell's suggestions are:

1. Teach less, and share more;
2. Be receptive;
3. Focus the child's attention without delay;
4. Look and experience first; talk later;
5. A sense of joy should permeate the experience. (pp. 11-14)

Rowley (1988), whose experience also lies in environmental education, proposes an adventure metaphor for education. He identifies 4 elements characteristic of educational adventures (A spirit of cooperation; High levels of engagement; Dealing with the dissonance that always accompanies change; The emergence of shared meaning), and argues that, in normal classwork, the teacher should take a leadership role in fostering a sense of shared adventure. Implicit in this sense of adventure is the notion of challenge

Similarly, teachers, students, and outside researchers can collaborate together to understand more about teaching and learning. Here again, the teacher-researcher could act as a classroom leader. Simply having teachers acting as researchers has been shown to change the nature of classrooms - teachers "become concerned about the impact of teaching on the children ... [they] become more responsive to the needs of the individual pupil ... [and] the classroom climate is likely to become more supportive and democratic" (Hopkins, 1987, p. 119). Ideally, these advances would be accompanied by a spirit of

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shared adventure, where cognitive and affective influences combine to provide positive, productive challenge. The challenge is to enter into careful, purposeful enquiry, based on reflection. (Indeed, as described above, the notion of challenge is itself a worthwhile focus for this reflection). If successful, the process will generate enhanced content understanding and metacognition that will, in turn, positively reinforce the likelihood for further engagement in, and commitment to, effective learning.

Some further findings regarding challenge

Two further studies were carried out in 1990. These studies were directed to exploring more fully the nature and extent of challenge for science teachers and students, and to identify which aspects of classwork are most in need of improvement. The first study involved intensive collaboration between individual teachers and students and a member of the project team. Over a period of 5 months, 7 teachers and 35 students in grades 7-10 were interviewed individually at approximately 3-weekly intervals. At each interview, each person was required to reflect upon what he or she thought and felt about various aspects of current lessons, and how these thoughts and feelings were translated into personal action. Each interview was centred on a particular focus for reflection. For instance, for teachers, the three main focuses were: 1 - Oneself and one's teaching; 2 - Learning and the students; 3 - How students perceive themselves and their learning. For each focus, there were five main objects of reflection. In Table 1, the objects of reflection associated with each of the 3 main teacher focuses are listed.

Table 1: Major focuses of reflection for teachers

Focus 1: Oneself and one's teaching

Objects of reflection are the teacher's perceptions of:

1. The nature of teaching and being a teacher.
2. Oneself.
3. Challenge in teaching.
4. Actual and desired teaching behaviours.
5. Actual and desired teaching outcomes.

Focus 2: Learning and the students

Objects of reflection are the teacher's perception of:

1. The nature of learning and being a learner.
2. Individual students.

3. Challenge for students in their learning.
4. Actual and desired student learning behaviours.
5. Actual and desired student learning outcomes.

Focus 3: How students perceive themselves and their learning

Objects of reflection are the teacher's perception of:

1. How students perceive the nature of learning and being a learner.
2. How students perceive themselves.
3. Extent to which students feel challenged in their learning.
4. What students perceive to be actual and desired learning behaviours.
5. What students believe to be actual and desired learning outcomes.

Each interview was structured according to a series of questions that probed each or the objects related to the particular focus. In each case, object number 3 concerns challenge directly. For this object, a series of questions were asked that systenfatically explored each of the nine factors that are taken to influence challenge (Figure 2). This study produced a variety of data that pertain to teachers' and students' perceptions of what challenges themselves and others, and the influence of challenge on personal lesson behaviours and outcomes. These data are currently being processed, and will be reported later this year as a series of detailed case studies.

The second study was designed to complement the first. Its purpose was to contrast the detailed, individually-based data arising from the case studies with more general survey information across year level, gender, and school boundaries. A detailed questionnaire, which probed each of the variables in Figure 2, was completed by a total of approximately 3900 students (1200 males, 2700 females) in grades 7-10 in 10 schools. The questionnaire provided large quantities of data that bear on students' perceptions of each variable and the influence of challenge (as demand and interest) on levels of personal engagement, application, and enjoyment. Space provides for only a scant mention of some findings arising from students' patterns of response.

Many of the findings from this questionnaire were similar to those obtained in previous questionnaires completed by other students in 1988 and 1989. Through their responses, students indicated that they want to be challenged in the work they do, but the level of challenge is often diminished by such factors as a lack of novelty and variety in classwork, inadequate personal control over lesson activities, and limited physical and, to a lesser extent, mental activity. Many students expressed their desire for more practical

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work, more diverse activities, and more fun, interesting topics. Most of these desires became more pronounced with increasing grade level. As students progress through grades 7-10, they feel that they are:

- understanding less;
- doing work that is less interesting, less varied, less enjoyable, more difficult, and less related to their interests;
- going too fast through the topics;
- less in control of lesson activities;
- less physically and mentally active.

Once again, the findings indicate that quality, as defined according to figures 1 and 2, is limited by various features of lesson content and context. These features can be linked to personal challenge and shared adventure. Once identified, they can provide a focus for attempts by teachers and students to improve classroom practice.

Conclusion

The four year research program reported in this paper yielded findings that illuminate how teachers' and students' perceptions of nine major features of the content and context of teaching and learning influence their classroom practice. The notion of Challenge, which comprises both cognitive and affective components, appears to be an important factor that mediates between thoughts and feelings, and behaviours. Challenge provides a focus for how teachers can structure purposeful enquiry among their students that will lead to improvement in the quality of their teaching and their students' learning.

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